Electronic Version
Stylesheet Version v1.1.1

Description

GOLF CLUB HEAD WITH CUSTOMIZABLE CENTER OF GRAVITY

Cross Reference to Related Applications

[0001] This application is a continuation application of co-pending U.S. Patent Application Number 10/249,510, filed on April 15, 2003, which is a continuation-in-part application of U.S. Patent Application Number 09/683,860, filed on February 22, 2002, now U.S. Patent Number 6,582,323, which is a continuation-in-part application of U.S. Patent Application 09/906,889, filed on July 16, 2001, now U.S. Patent Number 6,491,592, which is a continuation-in-part of U.S. Patent Application Number 09/431,982, filed November 1, 1999, now U.S. Patent Number 6,354,962.

Federal Research Statement

[0002] [Not Applicable]

Background of Invention

[0003] Field of the Invention

[0004] The present invention relates to a customizable golf club head and golf club. More specifically, the present invention relates to a method of customizing a golf club head with a face component and a plurality of aft-bodies that allow for multiple orientations of the center of gravity of the golf club head.

[0005] Description of the Related Art

[0006] When a golf club head strikes a golf ball, large impacts are produced that load the club head face and the golf ball. Most of the energy is transferred from the head to the golf ball, however, some energy is lost as a result of the collision. The golf ball is typically composed of polymer cover materials (such as ionomers) surrounding a rubber-like core. These softer polymer materials having damping (loss) properties that are strain and strain rate dependent which are on the order of 10-100 times larger than the damping properties of a metallic club face. Thus, during impact most of the energy is lost as a result of the high stresses and deformations of the golf ball (0.001 to 0.20 inch), as opposed to the small deformations of the metallic club face (0.025 to 0.050 inch). A more efficient energy

transfer from the club head to the golf ball could lead to greater flight distances of the golf ball.

[0007] The generally accepted approach has been to increase the stiffness of the club head face to reduce metal or club head deformations. However, this leads to greater deformations in the golf ball, and thus increases in the energy transfer problem.

[0008] Some have recognized the problem and disclosed possible solutions. An example is Campau, U.S. Patent Number 4,398,965, for a Method Of Making Iron Golf Clubs With Flexible Impact Surface, which discloses a club having a flexible and resilient face plate with a slot to allow for the flexing of the face plate. The face plate of Campau is composed of a ferrous material, such as stainless steel, and has a thickness in the range of 0.1 inches to 0.125 inches.

[0009] Another example is Eggiman, U.S. Patent Number 5,863,261, for a Golf Club Head With Elastically Deforming Face And Back Plates, which discloses the use of a plurality of plates that act in concert to create a spring-like effect on a golf ball during impact. A fluid is disposed between at least two of the plates to act as a viscous coupler.

[0010] Yet another example is Jepson *et al*, U.S. Patent Number 3,937,474, for a Golf Club With A Polyurethane Insert. Jepson discloses that the polyurethane insert has a hardness between 40 and 75 shore D.

[0011] Still another example is Inamori, U.S. Patent Number 3,975,023, for a Golf Club Head With Ceramic Face Plate, which discloses using a face plate composed of a ceramic material having a high energy transfer coefficient, although ceramics are usually harder materials. Chen et al., U.S Patent Number 5,743,813 for a Golf Club Head, discloses using multiple layers in the face to absorb the shock of the golf ball. One of the materials is a non-metal material.

[0012] Lu, U.S. Patent Number 5,499,814, for a Hollow Club Head With Deflecting Insert Face Plate, discloses a reinforcing element composed of a plastic or aluminum alloy that allows for minor deflecting of the face plate which has a thickness ranging from 0.01 to 0.30 inches for a variety of materials including stainless steel, titanium, KEVLAR®, and the like. Yet another Campau invention, U.S. Patent Number 3,989,248, for a Golf Club Having Insert Capable Of Elastic Flexing, discloses a wood club composed of wood with a metal insert.

[0013] Although not intended for flexing of the face plate, Viste, U.S. Patent Number 5,282,624, discloses a golf club head having a face plate composed of a forged stainless steel material and having a thickness of 3 mm. Anderson, U.S. Patent Number 5,344,140, for a Golf Club Head And Method Of Forming Same, also discloses the use of a forged material for the face plate. The face plate of Anderson may be composed of several forged materials including steel, copper and titanium. The forged plate has a uniform thickness of between 0.090 and 0.130 inch.

[0014] Another invention directed toward forged materials in a club head is Su *et al.*, U.S. Patent Number 5,776,011 for a Golf Club Head. Su discloses a club head composed of three pieces with each piece composed of a forged material. The main objective of Su is to produce a club head with greater loft angle accuracy and reduce structural weaknesses. Aizawa, U.S. Patent Number 5,346,216 for a Golf Club Head, discloses a face plate having a curved ball hitting surface.

[0015] U.S. Patent 6,146,571 to Vincent, *et.al.*, discloses a method of manufacturing a golf club head wherein the walls are obtained by injecting a material, such as plastic, over an insert affixed to a meltable core. The core has a melt

point lower than that of the injectable plastic material so that once the core is removed, an inner volume is maintained to form the inner cavity. The insert may comprise a resistance element for reinforcing the internal portion of the front wall of the shell upon removal of the core where the reinforcement element is comprised of aluminum with a laterally extending portion comprised of steel.

[0016] U.S. Patent 6,149,534 to Peters, *et al.*, discloses a golf club head having upper and lower metal engagement surfaces formed along a single plane interface wherein the metal of the lower surface is heavier and more dense than the metal of the upper surface.

[0017] U.S. Patents 5,570,886 and 5,547,427 to Rigal, *et al.*, disclose a golf club head of molded thermoplastic having a striking face defined by an impact-resistant metallic sealing element. The sealing element defines a front wall of the striking surface of the club head and extends upward and along the side of the impact surface to form a neck for attachment of the shaft to the club head. The sealing element preferably being between 2.5 and 5 mm in thickness.

[0018] U.S. Patent 5,425,538 to Vincent, *et al.*, discloses a hollow golf club head having a steel shell and a composite strik-

ing surface composed of a number of stacked woven webs of fiber.

[0019] U.S. Patent 5,377,986 to Viollaz, *et al.*, discloses a golf club head having a body composed of a series of metal plates and a hitting plate comprised of plastic or composite material wherein the hitting plate is imparted with a forwardly convex shape. Additionally, U.S. Patent Number 5,310,185 to Viollaz, *et al.*, discloses a hollow golf club head having a body composed of a series of metal plates, a metal support plate being located on the front hitting surface to which a hitting plate comprised of plastic or composite is attached. The metal support plate has a forwardly convex front plate associated with a forwardly convex rear plate of the hitting plate thereby forming a forwardly convex hitting surface.

[0020] U.S. Patent Number 5,106,094 to Desboilles, *et al.*, discloses a golf club head having a metal striking face plate wherein the striking face plate is a separate unit attached to the golf club head with a quantity of filler material in the interior portion of the club head.

[0021] U.S. Patent Number 4,568,088 to Kurahashi discloses a wooden golf club head body reinforced by a mixture of wood-plastic composite material. The wood-plastic com-

posite material is unevenly distributed such that a higher density in the range of between 5 and 15 mm lies adjacent to and extends substantially parallel with the front face of the club head.

[0022] U.S. Patent Number 4,021,047 to Mader discloses a golf club wherein the sole plate, face plate, heel, toe and hosel portions are formed as a unitary cast metal piece and wherein a wood or composite crown is attached to this unitary piece thereby forming a hollow chamber in the club head.

[0023] U.S. Patent Number 5,624,331 to Lo, *et al.* discloses a hollow metal golf club head where the metal casing of the head is composed of at least two openings. The head also contains a composite material disposed within the head where a portion of the composite material is located in the openings of the golf club head casing.

[0024] U.S. Patent Number 1,167,387 to Daniel discloses a hollow golf club head wherein the shell body is comprised of metal such as aluminum alloy and the face plate is comprised of a hard wood, such as beech, persimmon or the like. The face plate is aligned such that the wood grain presents endwise at the striking plate.

[0025] U.S. Patent Number 3,692,306 to Glover discloses a golf

club head having a bracket with sole and striking plates formed integrally thereon. At least one of the plates has an embedded elongate tube for securing a removably adjustable weight means.

[0026] U.S. Patent Number 5,410,798 to Lo discloses a method of manufacturing a composite golf club head using a metal casing to which a laminated member is inserted. A sheet of composite material is subsequently layered over the openings of the laminated member and metal casing to close off the openings in the top of both. An expansible pocket is then inserted into the hollow laminated member comprising sodium nitrite, ammonium chloride and water causing the member to attach integrally to the metal casing when the head is placed into a mold and heated.

[0027] U.S. Patent Number 4,877,249 to Thompson discloses a wood golf club head embodying a laminated upper surface and metallic sole surface having a keel. In order to reinforce the laminations and to keep the body from delaminating upon impact with an unusually hard object, a bolt is inserted through the crown of the club head where it is connected to the sole plate at the keel and tightened to compress the laminations.

[0028] U.S. Patent Number 3,897,066 to Belmont discloses a

wooden golf club head having removably inserted weight adjustment members. The members are parallel to a central vertical axis running from the face section to the rear section of the club head and perpendicular to the crown to toe axis. The weight adjustment members may be held in place by the use of capsules filled with polyurethane resin, which can also be used to form the faceplate. The capsules have openings on a rear surface of the club head with covers to provide access to adjust the weight means.

[0029] U.S. Patent Number 2,750,194 to Clark discloses a wooden golf club head with weight adjustment means. The golf club head includes a tray member with sides and bottom for holding the weight adjustment preferably cast or formed integrally with the heel plate. The heel plate with attached weight member is inserted into the head of the golf club via an opening.

[0030] U.S. Patent Number 5,193,811 to Okumoto, *et al.* discloses a wood type club head body comprised primarily of a synthetic resin and a metallic sole plate. The metallic sole plate has on its surface for bonding with the head body integrally formed members comprising a hosel on the heel side, weights on the toe and rear sides and a beam connecting the weights and hosel. Additionally, U.S. Patent

5,516,107 to Okumoto, *et al.*, discloses a golf club head having an outer shell, preferably comprised of synthetic resin, and metal weight member/s located on the interior of the club head. A foamable material is injected into the hollow interior of the club to form the core. Once the foamable material has been injected and the sole plate is attached, the club head is heated to cause the foamable material to expand thus holding the weight member/s in position in recess/es located in toe, heel and/or back side regions by pushing the weight member/s into the inner surface of the outer shell.

[0031] U.S. Patent Number 4,872,685 to Sun discloses a wood type golf club head wherein a female unit is mated with a male unit to form a unitary golf club head. The female unit comprises the upper portion of the golf club head and is preferably composed of plastic, alloy, or wood. The male unit includes the structural portions of sole plate, a face insert consists of the striking plate and weighting elements. The male unit has a substantially greater weight and is preferably composed of a light metal alloy. The units are mated or held together by bonding and or mechanical means.

[0032] U.S. Patent Number 5,398,935 to Katayama discloses a

wood golf club head having a striking face wherein the height of the striking face at a toe end of the golf club head is nearly equal to or greater than the height of the striking face at the center of the club head.

[0033] U.S. Patent Number 1,780,625 to Mattern discloses a club head with a rear portion composed of a light-weight metal, such as magnesium. U.S. Patent Number 1,638,916 to Butchart discloses a golf club with a balancing member composed of persimmon or a similar wood material, and a shell-like body composed of aluminum attached to the balancing member.

[0034] The Rules of Golf, established and interpreted by the United States Golf Association ("USGA") and The Royal and Ancient Golf Club of Saint Andrews, set forth certain requirements for a golf club head. The requirements for a golf club head are found in Rule 4 and Appendix II. A complete description of the Rules of Golf are available on the USGA web page at www.usga.org. Although the Rules of Golf do not expressly state specific parameters for a golf club face, Rule 4-1e prohibits the face from having the effect at impact of a spring with a golf ball. In 1998, the USGA adopted a test procedure pursuant to Rule 4-1e which measures club face COR. This USGA test procedure,

as well as procedures like it, may be used to measure club face COR.

[0035] Existing large volume driver heads (>300cc) composed of conventional materials (titanium, steel) and conventional manufacturing methods (casting, forging, MIM, machining, etc.) are limited in the amount of discretionary material available for adjusting the center of gravity location of the golf club head. This limits the ability to customize the performance characteristics of the head to best suit a particular player or segment of players. Further, the center of gravity is not readily adjustable since the discretionary mass is in the form of parent metal or a discrete weight chip, both of which are established early in the head manufacturing process. Therefore, customizing the center of gravity of conventional head designs is generally difficult and ineffective.

SUMMARY OF INVENTION

[0036] The present invention provides a means for fabricating heads having a center of gravity location that is determined late in the manufacturing process and that is selected to be appropriate for a specific player or player segment. The present invention preferably includes a face component and interchangeable aft-body components

that are pre-manufactured and then selected for assembly based on the desired center of gravity location for that specific golf club head. The center of gravity location of the golf club head is preferably varied independently in the heel-toe and sole-crown directions to achieve desired levels of side spin and back spin for the specific player type. Golf club performance (trajectory and shot shape) is improved by adjusting the spin characteristics of the golf club head to better match the player type. A golf club having a tendency to provide a draw (right to left) shot shape can be provided to players who tend to hit a fade or slice (left to right). Also, a golf club having a tendency to provide a higher golf ball trajectory can be provided to players who tend to hit the golf ball lower than desired.

[0037] One aspect of the invention is a multi-material golf club head including a metallic face component and a non-metallic aft-body component that is bonded to the face component.

[0038] Another aspect of the present invention are weighting elements that are either integral to the aft-body component or are secondarily attached either to the inside or outside surface of the aft-body component. A composite laminated aft-body preferably has the weighting elements co-

bonded within the body during curing of the composite laminate. An injection molded aft-body preferably has the weighting elements co-molded with the aft-body. The weighting elements are preferably composed of a high-density material (greater than five grams per cubic centimeter), such as loaded urethane, copper or tin alloy material.

[0039] The weighting elements are preferably positioned within the aft-body (preferably in the ribbon area) to provide a desired center of gravity position for the assembled head. The preferred configuration consists of the minimum necessary quantity of weighting elements needed to achieve the desired range of center of gravity locations. Ideally, a single asymmetric weighting element would be rotated and/or repositioned to achieve a range of center of gravity positions. More practically, a multiple set of weighting elements would be used to achieve such center of gravity positions, either by repositioning individual weighting elements or by replacing certain elements with other elements having differing mass. The total mass of the golf club head is preferably held constant even though the center of gravity varies, although in some cases it may be desirable to also vary total golf club head mass as the

center of gravity is varied in the golf club head.

[0040] In a preferred embodiment, the ribbon walls of the golf club head are near vertical so that as weight elements are repositioned, the inertial properties Iyy and Izz are minimally affected. Also, vertical or near vertical ribbon walls in the golf club head de-couple the Ycg and Zcg properties from Xcg, enabling them to be adjusted independent of each other. In the case of golf club heads having sharply contoured (non-vertical) ribbon walls, changes in Ycg and Zcg are often accompanied by degradation in Iyy and Izz, which results in reduced forgiveness and straightness of the golf club head. Also, in this case, changes in Ycg and Zcg are also accompanied by changes in Xcg.

[0041] Another aspect of the present invention is assembly of the aft-body to the face component at a late stage of fabrication thereby allowing for any one of many aft-bodies, each having different center of gravity locations, to be bonded to the face component. Such late-stage assembly allows for mass customization of the center of gravity of a golf club head for high volume manufacturing.

[0042] Another aspect of the present invention is selection and attachment of the weighting elements to the aft-body af-

ter the face component and the aft-body have been bonded together. Such post-bonding attachment provides for a range of center of gravity types in quantities that best match the projected demand.

[0043] Having briefly described the present invention, the above and further objects, features and advantages thereof will be recognized by those skilled in the pertinent art from the following detailed description of the invention when taken in conjunction with the accompanying drawings.

Brief Description of Drawings

[0044] FIG. 1 is a front view of a golf club.

[0045] FIG. 1A is a front view of a golf club illustrating the measurement for the aspect ratio.

[0046] FIG. 2 is a rear view of a golf club head.

[0047] FIG. 3 is toe side view of the golf club head of FIG. 2.

[0048] FIG. 4 is a heel side plan view of the golf club head of FIG. 2.

[0049] FIG. 5 is a top plan view of the golf club head of FIG. 2.

[0050] FIG. 6 is a bottom view of the golf club head of FIG. 2.

[0051] FIG. 6A is a bottom perspective view of the golf club head of FIG. 2FIG. 7 is a cross-sectional of the golf club head of

FIG. 5.

[0052] FIG. 7 is a cross-sectional of the golf club head of FIG. 5.

[0053] FIG. 8 is an isolated cross-sectional view of the face component overlapping the aft body.

[0054] FIG. 9 is a heel side plan view of a golf club of the present invention illustrating the Z axis and X axis.

[0055] FIG. 10 is a front plan view of a golf club of the present invention illustrating the Z axis and Y axis.

[0056] FIG. 11 is a front plan view of a golf club illustrating the test frame coordinates X^T and Y^T and transformed head frame coordinates Y^H and Z^H.

[0057] FIG. 11A is a toe end view of the golf club illustrating the test frame coordinate Z^T and transformed head frame coordinates X^H and Z^H.

[0058] FIG. 12 is an isolated rear perspective view of a face component of the golf club.

[0059] FIG. 13 is an isolated front view of a face component of the golf club head.

[0060] FIG. 13A is an interior view of the face component of FIG. 13.

[0061] FIG. 13B is a bottom plan view of the face component of FIG. 13.

[0062] FIG. 13C is a top plan view of the face component of FIG.

13.

[0063] FIG. 13D is a toe side view of the face component of FIG. 13.

[0064] FIG. 13E is a heel side view of the face component of FIG. 13.

[0065] FIG. 14 is an isolated top plan view of an aft-body of the golf club head.

[0066] FIG. 14A is an interior view of the aft-body of FIG. 14.

[0067] FIG. 14B is a heel side view of the aft-body of FIG. 14.

[0068] FIG. 14C is a toe side view of the aft-body of FIG. 14.

[0069] FIG. 14D is a bottom plan view of the aft-body of FIG. 14.

[0070] FIG. 14E is a rear view of the aft-body of FIG. 14.

[0071] FIG. 14F is a bottom perspective view of the aft-body of FIG. 14.

[0072] FIG. 15 is a rear view of a golf club head with a weight member placed for customization.

[0073] FIG. 15A is a rear view of a golf club head with an alternative placement of a weight member for customization.

[0074] FIG. 15B is a rear view of a golf club head with an alternative placement of weight members for customization.

[0075] FIG. 15C is a rear view of a golf club head with an alterna-

tive placement of weight members for customization.

[0076] FIG. 15D is a rear view of a golf club head with an alternative placement of weight members for customization.

[0077] FIG. 15E is a rear view of a golf club head with an alternative placement of weight members for customization.

[0078] FIG. 16 is a front view of a golf club head illustrating areas of bias for the center of gravity of the golf club head.

[0079] FIG. 16A is a top view of the golf club head of FIG. 16.

[0080] FIG. 17 is a front view of a golf club head illustrating alternative areas of bias for the center of gravity of the golf club head.

[0081] FIG. 17A is a top view of the golf club head of FIG. 17.

[0082] FIG. 18 is a front view of a golf club head illustrating alternative areas of bias for the center of gravity of the golf club head.

[0083] FIG. 18A is a top view of the golf club head of FIG. 18.

[0084] FIG. 19 is a front view of a golf club head illustrating alternative areas of bias for the center of gravity of the golf club head.

[0085] FIG. 19A is a top view of the golf club head of FIG. 19.

[0086] FIG. 20 is a front view of a golf club head illustrating alternative areas of bias for the center of gravity of the golf

club head.

[0087] FIG. 20A is a top view of the golf club head of FIG. 20.

[0088] FIG. 21 is a front view of a golf club head illustrating alternative areas of bias for the center of gravity of the golf club head.

[0089] FIG. 21A is a top view of the golf club head of FIG. 21.

[0090] FIG. 22 is a graph of the change in side spin versus the change in the horizontal position (from heel to toe) of the center of gravity of the golf club head.

[0091] FIG. 23 is a graph of the change in back spin versus the change in the vertical position (from crown to sole) of the center of gravity of the golf club head.

DETAILED DESCRIPTION

[0092] As shown in FIGS. 1-5, a golf club is generally designated 40. The golf club 40 has a golf club head 42 with a hollow interior, not shown. Engaging the club head 42 is a shaft 48 that has a grip 50, not shown, at a butt end 52 and is inserted into a hosel 54 at a tip end 56.

[0093] The club head 42 is generally composed of two components, a face component 60, and an aft-body 61. The aft-body 61 has a crown portion 62 and a sole portion 64. The club head 42 is preferably partitioned into a heel sec-

tion 66 nearest the shaft 48, a toe section 68 opposite the heel section 66, and a rear section 70 opposite the face component 60. A sole weight member 133 is disposed within a sole undercut portion 133a of the sole portion. The sole weighing member has a mass ranging from 0.5 grams to 15 grams.

[0094] The face component 60 is generally composed of a single piece of metal, and is preferably composed of a forged metal material. More preferably, the forged metal material is a forged titanium material. Such titanium materials include pure titanium and titanium alloys such as 6-4 titanium alloy, SP-700 titanium alloy (available from Nippon Steel of Tokyo, Japan), DAT 55G titanium alloy available from Diado Steel of Tokyo, Japan, Ti 10-2-3 Beta-C titanium alloy available from RTI International Metals of Ohio, and the like. Other metals for the face component 60 include stainless steel, other high strength steel alloy metals and amorphous metals. Alternatively, the face component 60 is manufactured through casting, forming, machining, powdered metal forming, metal-injection-molding, electro chemical milling, and the like.

[0095] FIGS. 12, 13, 13A, 13B, 13C, 13D and 13E illustrate the face component 60 in isolation. The face component 60

generally includes a striking plate portion (also referred to herein as a face plate) 72 and a return portion 74 extending laterally inward from the perimeter 73 of the striking plate portion 72. The striking plate portion 72 typically has a plurality of scorelines 75 thereon. The striking plate portion 72 has a thickness ranging from 0.010 inch to 0.250 inch, and the return portion 74 has a thickness ranging from 0.010 inch to 0.250 inch. The return portion 74 extends a distance ranging from 0.25 inch to 1.5 inches from the perimeter 73 of the striking plate portion 72.

[0096] In a preferred embodiment, the return portion 74 generally includes an upper lateral section 76, a lower lateral section 78 with a sole extension 95, a heel lateral section 80 and a toe lateral section 82. Thus, the return 74 preferably encircles the striking plate portion 72 a full 360 degrees. However, those skilled in the pertinent art will recognize that the return portion 74 may only encompass a partial section of the striking plate portion 72, such as 270 degrees or 180 degrees, and may also be discontinuous.

[0097] The upper lateral section 76 extends inward, towards the aft-body 61, a predetermined distance, d, to engage the

crown 62. In a preferred embodiment, the predetermined distance ranges from 0.2 inch to 1.0 inch, more preferably 0.40 inch to 0.75 inch, and most preferably 0.68 inch, as measured from the perimeter 73 of the striking plate portion 72 to the rearward edge of the upper lateral section 76. In a preferred embodiment, the upper lateral section 76 has a general curvature from the heel section 66 to the toe section 68. The upper lateral section 76 has a length from the perimeter 73 of the striking plate section 72 that is preferably a minimal length near the center of the striking plate section 72, and increases toward the toe section 68 and the heel section 66.

[0098] The perimeter 73 of the striking plate portion 72 is defined as the transition point where the face component 60 transitions from a plane substantially parallel to the striking plate portion 72 to a plane substantially perpendicular to the striking plate portion 72. Alternatively, one method for determining the transition point is to take a plane parallel to the striking plate portion 72 and a plane perpendicular to the striking plate portion, and then take a plane at an angle of forty-five degrees to the parallel plane and the perpendicular plane. Where the forty-five degrees plane contacts the face component is the transition point

thereby defining the perimeter of the striking plate portion 72.

[0099] The present invention preferably has the face component 60 engage the crown 62 along a substantially horizontal plane. The crown 62 has a crown undercut portion 62a, which is placed under the return portion 74. Such an engagement enhances the flexibility of the striking plate portion 72 allowing for a greater coefficient of restitution. The crown 62 and the upper lateral section 76 are attached to each other as further explained below.

[0100] The heel lateral section 80 is substantially perpendicular to the striking plate portion 72, and the heel lateral section 80 covers the hosel 54 before engaging an optional ribbon section 90 and a bottom section 91 of the sole portion 64 of the aft-body 61. The heel lateral section 80 is attached to the sole 64, both the ribbon 90 and the bottom section 91, as explained in greater detail below. The heel lateral section 80 extends inward a distance, d"', from the perimeter 73 a distance of 0.250 inch to 1.50 inches, more preferably 0.50 inch to 1.0 inch, and most preferably 0.950 inch. The heel lateral section 80 preferably has a general curvature at its edge.

[0101] At the other end of the face component 60 is the toe lat-

eral section 82. The toe lateral section 82 is attached to the sole 64, both the ribbon 90 and the bottom section 91, as explained in greater detail below. The toe lateral section 82 extends inward a distance, d", from the perimeter 73 a distance of 0.250 inch to 1.50 inches, more preferably 0.75 inch to 1.30 inch, and most preferably 1.20 inch. The toe lateral section 82 preferably has a general curvature at its edge.

[0102] The lower lateral section 78 extends inward, toward the aft-body 61, a distance, d", to engage the sole 64, and a sole extension 95 extends further inward a distance d^S to preferably function as protection for the sole of the club head 42. In a preferred embodiment, the distance d' ranges from 0.2 inch to 1.25 inches, more preferably 0.50 inch to 1.10 inch, and most preferably 0.9 inch, as measured from the perimeter 73 of the striking plate portion 72 to the edge of the lower lateral section 78. In a preferred embodiment, the distance d^S ranges from 0.2 inch to 3.0 inches, more preferably 0.50 inch to 2.0 inches, and most preferably 1.50 inch, as measured from the edge of the lower lateral section 78 to an apex 97 of the sole extension 95. In a preferred embodiment, the sole extension 95 is triangular in shape with minor apices 99.

In an alternative embodiment, not shown, the sole extension 95 has a crescent shape. In yet a further alternative, not shown, the sole extension 95 has a rectangular shape, and extends to the ribbon 90. Those skilled in the pertinent art will recognize that the sole extension 95 may have various shapes and sizes without departing from the scope and spirit of the present invention.

[0103] The sole portion 64 has a sole undercut 64a for placement under the return portion 74. The sole extension 95 is disposed within a sole undercut extension 64aa. The sole 64 and the lower lateral section 78, the heel lateral section 80 and the toe lateral section 82 are attached to each other as explained in greater detail below.

[0104] The aft-body 61 is preferably composed of a non-metal material, preferably a composite material such as continuous fiber pre-preg material (including thermosetting materials or a thermoplastic materials for the resin). Other materials for the aft-body 61 include other thermosetting materials or other thermoplastic materials such as injectable plastics. Alternatively, the aft-body 61 is composed of low-density metal materials such as magnesium or aluminum.

[0105] The aft-body 61 is preferably manufactured through

bladder-molding, resin transfer molding, resin infusion, injection molding, compression molding, or a similar process. In a preferred process, the face component 60, with an adhesive on the interior surface of the return portion 74, is placed within a mold with a preform of the aft-body 61 for bladder molding. The return portion 74 is placed and fitted into the undercut portions 62a and 64a. Also, the adhesive may be placed on the undercut portions 62a and 64a. Such adhesives include thermosetting adhesives in a liquid or a film medium. A preferred adhesive is a two part liquid epoxy sold by 3M of Minneapolis Minnesota under the brand names DP420NS and DP460NS. Other alternative adhesives include modified acrylic liquid adhesives such as DP810NS, also sold by the 3M company. Alternatively, foam tapes such as Hysol Synspan may be utilized with the present invention.

[0106] A bladder is placed within the hollow interior of the preform and face component 60, and is pressurized within the mold, which is also subject to heating. The co-molding process secures the aft-body 61 to the face component 60. Alternatively, the aft-body 61 is bonded to the face component 60 using an adhesive, or mechanically secured to the return portion 74.

[0107] As shown in FIG. 8, the return portion 74 overlaps the undercut portions 62a and 64a a distance Lo, which preferably ranges from 0.25 inch to 1.00 inch, more preferably ranges from 0.40 inch to 0.70 inch, and is most preferably 0.50 inch. An annular gap 170 is created between an edge 190 of the crown portion 62 and the sole portion 64, and an edge 195 of the return portion 74. The annular gap 170 preferably has a distance Lg that preferably ranges from 0.020 inch to 0.100 inch, more preferably from 0.050 inch to 0.070 inch, and is most preferably 0.060 inch. A projection 175 from an upper surface of the undercut portions 62a and 64a establishes a minimum bond thickness between the interior surface of the return portion 74 and the upper surface of the undercut portions 62a and 64a. The bond thickness preferably ranges from 0.002 inch to 0.100 inch, more preferably ranges from 0.005 inch to 0.040 inch, and is most preferably 0.030 inch. A liquid adhesive 200 preferably secures the aft body 61 to the face component 60. A leading edge 180 of the undercut portions 62a and 64a may be sealed to prevent the liquid adhesive from entering the hollow interior 46.

[0108] FIGS. 14, 14A, 14B, 14C 14D, 14E, and 14F illustrate a

preferred embodiment of the aft-body 61. The crown portion 62 of the aft-body 61 is generally convex toward the sole 64, and engages the ribbon 90 of sole 64 outside of the engagement with the face member 60. The crown portion 62 preferably has a thickness in the range of 0.010 to 0.100 inch, more preferably in the range of 0.025 inch to 0.070 inch, even more preferably in the range of 0.028 inch to 0.040 inch, and most preferably has a thickness of 0.033 inch. The sole portion 64, including the bottom section 91 and the optional ribbon 90 which is substantially perpendicular to the bottom section 91, preferably has a thickness in the range of 0.010 to 0.100 inch, more preferably in the range of 0.025 inch to 0.070 inch, even more preferably in the range of 0.028 inch to 0.040 inch, and most preferably has a thickness of 0.033 inch. The undercut portions 62a, 64a, 64aa and 133a have a similar thickness to the sole portion 64 and the crown portion 62. In a preferred embodiment, the aft-body 61 is composed of a plurality of plies of pre-preg, typically six or seven plies, such as disclosed in U.S. Patent Number 6,248,025, entitled Composite Golf Head And Method Of Manufacturing, which is hereby incorporated by reference in its entirety. The bottom section 91 is

generally convex toward the crown portion 62. An optional bladder port 135 is located in the sole undercut portion 64a.

[0109] FIG. 7 illustrates the hollow interior 46 of the club head 42 of the present invention. The hosel 54 is disposed within the hollow interior 46, and is located as a part of the face component 60, as shown in FIG. 12. The hosel 54 may be composed of a similar material to the face component 60, and is preferably secured to the face component 60 through welding or the like. The hosel 54 may also be formed with the formation of the face component 60. Additionally, the hosel may be composed of a non-similar material that is light weight and secured using bonding or other mechanical securing techniques. A hollow interior 118 of the hosel 54 is defined by a hosel wall 120 that forms a tapering tube from the aperture 59 to the sole potion 64. In a preferred embodiment, the hosel wall 120 does not engage the heel lateral section 80 thereby leaving a void 115 between the hosel wall 120 and the heel lateral section 80. The shaft 48 is disposed within a hosel insert 121 that is disposed within the hosel 54. Such a hosel insert 121 and hosel 54 are described in U.S. Patent Number 6,352,482, filed on August 31, 2000, entitled

Golf Club With Hosel Liner, which pertinent parts are hereby incorporated by reference. Further, the hosel 54 is preferably located rearward from the striking plate portion 72 in order to allow for compliance of the striking plate portion 72 during impact with a golf ball. In one embodiment, the hosel 54 is disposed 0.125 inch rearward from the striking plate portion 72.

[0110] As shown in FIG. 7, a weight member 122 is preferably disposed within the hollow interior 46 of the club head 42. In a preferred embodiment, the weight member 122 is disposed on the interior surface of the ribbon section 90 of the sole portion 64 in order to increase the moment of inertia and control the center of gravity of the golf club head 42. However, those skilled in the pertinent art will recognize that the weight member 122, and additional weight members 122 may be placed in other locations of the club head 42 in order to influence the center of gravity, moment of inertia, or other inherent properties of the golf club head 42. The weight member 122 is preferably tungsten loaded film, tungsten doped polymers, or similar weighting mechanisms such as described in U.S. Patent Number 6,386,990, filed on December 29, 1999, entitled A Composite Golf Club Head With An Integral Weight Strip,

and hereby incorporated by reference in its entirety. Those skilled in the pertinent art will recognize that other high density materials may be utilized as an optional weight member without departing from the scope and spirit of the present invention.

[0111] As illustrated in FIG. 14A, in one embodiment the weight member 122 is composed of three weighting components 122a, 122b and 122c, which are embedded within the plies of pre-preg of the ribbon section 90 of the sole portion 64 of the aft-body 61. A heel weight component 122a, a center weight component 122b and a toe weight component 122c are all disposed within the plies of pre-preg that compose the ribbon section 90. Individually, each of the weight components 122a-c has a mass ranging from 10 grams to 30 grams, preferably from 14 grams to 25 grams, and more preferably from 15 grams to 20 grams. Each of the weight components 122a-c has a density ranging from 5 grams per cubic centimeters to 20 grams per cubic centimeters, more preferably from 7 grams per cubic centimeters to 12 grams per cubic centimeters, and most preferably 8.0 grams per cubic centimeters.

[0112] Each of the weight components 122a-c is preferably com-

posed of a polymer material integrated with a metal material. The metal material is preferably selected from copper, tungsten, steel, aluminum, tin, silver, gold, platinum, or the like. A preferred metal is tungsten due to its high density. The polymer material is a thermoplastic or thermosetting polymer material. A preferred polymer material is polyurethane, epoxy, nylon, polyester, or similar materials. A most preferred polymer material is a thermoplastic polyurethane. A preferred weight component 122a, 122b or 122c is an injection molded thermoplastic polyurethane integrated with tungsten to have a density of 8.0 grams per cubic centimeters. In a preferred embodiment, each of the weight components 122a-c is composed of from 50 to 95 volume percent polyurethane and from 50 to 5 volume percent tungsten. Also, in a preferred embodiment, each of the weight components 122a-c is composed of from 10 to 25 weight percent polyurethane and from 90 to 75 weight percent tungsten.

[0113] Preferably, the weight components 122a-c extend from approximately the heel section 66 of the striking plate portion 72 through the rear section 70 to the toe section 68 of the striking plate portion 72. However, the weight components 122a-c may only extend along the rear sec-

tion 70 of the ribbon section 90, the heel section 66 of the ribbon section 90, the toe section 68 of the ribbon section 90, or any combination thereof. Also, the weight components 122a-c may be positioned parallel to each other as opposed to being positioned in series. Those skilled in the pertinent art will recognize that other weighting materials may be utilized for the weight components 122a-c without departing from the scope and spirit of the present invention. The placement of the weighting components 122a-c allows for the moment of inertia of the golf club head 40 to be optimized.

[0114] FIG. 13A illustrates a preferred embodiment of the face component 60 of the golf club head 42. FIG. 13A illustrates the variation in the thickness of the striking plate portion 72. The striking plate portion 72 is preferably partitioned into elliptical regions, each having a different thickness. In a preferred embodiment in which the face component 60 is composed of a titanium or titanium alloy material, a central elliptical region 102 preferably has the greatest thickness that ranges from 0.120 inch to 0.090 inch, preferably from 0.115 inch to 0.100 inch, and is most preferably 0.105 inch. The central elliptical region 102 preferably has a uniform thickness. A first concentric

region 104 preferably has the next greatest thickness that ranges from 0.110 inch to 0.076 inch, preferably from 0.100 inch to 0.086 inch, and is most preferably 0.088 inch. The first concentric region preferably has a thickness that transitions from the first concentric region 102 thickness to the periphery region 110 thickness. A periphery region 110 preferably has the next greatest thickness that ranges from 0.082 inch to 0.062 inch, and is most preferably 0.072 inch. The variation in the thickness of the striking plate portion 72 allows for the greatest thickness to be localized in the center 111 of the striking plate portion 72 thereby maintaining the flexibility of the striking plate portion 72 which corresponds to less energy loss to a golf ball and a greater coefficient of restitution without reducing the durability of the striking plate portion 72.

[0115] FIG. 12 illustrated face component 60 with an optional face component weighting section 113, which provides greater mass to the face component 60 for forward positioning of the center of gravity and heel and toe biasing of the golf club 40. The weighting section 113 is preferably an area of increased thickness. Alternatively, the weighting section 113 is an additional weight welded to the interior surface of the return portion 74 of the face compo-

nent 60.

[0116] As mentioned previously, the face component 60 is preferably forged from a rod of metal material. One preferred forging process for manufacturing the face component is set forth in U.S. Patent Number 6,440,011, filed on April 13, 2000, entitled Method For Processing A Striking Plate For A Golf Club Head, and hereby incorporated by reference in its entirety. Alternatively, the face component 60 is cast from molten metal in a method such as the well-known lost-wax casting method. The metal for forging or casting is preferably titanium or a titanium alloy such as 6-4 titanium alloy, alpha-beta titanium alloy or beta titanium alloy for forging, and 6-4 titanium for casting.

[0117] Additional methods for manufacturing the face component 60 include forming the face component 60 from a flat sheet of metal, super-plastic forming the face component 60 from a flat sheet of metal, machining the face component 60 from a solid block of metal, electrochemical milling the face from a forged pre-form, and like manufacturing methods. Yet further methods include diffusion bonding titanium sheets to yield a variable face thickness face and then superplastic forming.

[0118] Alternatively, the face component 60 is composed of an amorphous metal material such as disclosed in U.S. Patent Number 6,471,604, which was filed on April 4, 2002 and is hereby incorporated by reference in its entirety.

[0119] The present invention is directed at a golf club head that has a high coefficient of restitution thereby enabling for greater distance of a golf ball hit with the golf club head of the present invention. The coefficient of restitution (also referred to herein as "COR") is determined by the following equation:

$$e = \frac{v_2 - v_1}{U_1 - U_2}$$

[0120] wherein U_1 is the club head velocity prior to impact; U_2 is the golf ball velocity prior to impact which is zero; v_1 is the club head velocity just after separation of the golf ball from the face of the club head; v_2 is the golf ball velocity just after separation of the golf ball from the face of the

club head; and e is the coefficient of restitution between the golf ball and the club face.

[0121] The values of e are limited between zero and 1.0 for systems with no energy addition. The coefficient of restitution, e, for a material such as a soft clay or putty would be near zero, while for a perfectly elastic material, where no energy is lost as a result of deformation, the value of e would be 1.0. The present invention provides a club head having a coefficient of restitution ranging from 0.81 to 0.94, as measured under conventional test conditions.

[0122] The coefficient of restitution of the club head 42 of the present invention under standard USGA test conditions with a given ball ranges from approximately 0.81 to 0.94, preferably ranges from 0.83 to 0.883 and is most preferably 0.87.

[0123] Additionally, the striking plate portion 72 of the face component 60 has a smaller aspect ratio than face plates of the prior art. The aspect ratio as used herein is defined as the width, "W", of the face divided by the height, "H", of the face, as shown in FIG. 1A. In one preferred embodiment, the width W is 78 millimeters and the height H is 48 millimeters giving an aspect ratio of 1.625. In conventional golf club heads, the aspect ratio is usually much

greater than 1. For example, the original GREAT BIG BERTHA® driver had an aspect ratio of 1.9. The striking plate portion 72 of the present invention has an aspect ratio that is no greater than 1.7. The aspect ratio of the present invention preferably ranges from 1.0 to 1.7. One embodiment has an aspect ratio of 1.3. The striking plate portion 72 of the present invention is more circular than faces of the prior art. The face area of the striking plate portion 72 of the present invention ranges from 4.00 square inches to 7.50 square inches, more preferably from 5.00 square inches to 6.5 square inches, and most preferably from 5.8 square inches to 6.0 square inches.

[0124] The club head 42 of the present invention also has a greater volume than a club head of the prior art while maintaining a weight that is substantially equivalent to that of the prior art. The volume of the club head 42 of the present invention ranges from 290 cubic centimeters to 600 cubic centimeters, and more preferably ranges from 350 cubic centimeters to 510 cubic centimeters, even preferably 360 cubic centimeters to 395 cubic centimeters, and most preferably 385 cubic centimeters.

[0125] The mass of the club head 42 of the present invention ranges from 165 grams to 225 grams, preferably ranges

from 175 grams to 205 grams, and most preferably from 190 grams to 200 grams. Preferably, the face component 60 has a mass ranging from 50 grams to 110 grams, more preferably ranging from 65 grams to 95 grams, yet more preferably from 70 grams to 90 grams, and most preferably 78 grams. The aft-body 61 (without weighting) has a mass preferably ranging from 10 grams to 60 grams, more preferably from 15 grams to 50 grams, and most preferably 35 grams to 40 grams. The weight member 122 (preferably composed of three separate weight members 122a, 122b and 122c) has a mass preferably ranging from 30 grams to 120 grams, more preferably from 50 grams to 80 grams, and most preferably 60 grams. The interior hosel 54 preferably a mass preferably ranging from 3 grams to 20 grams, more preferably from 5 grams to 15 grams, and most preferably 12 grams. Additionally, epoxy, or other like flowable materials, in an amount ranging from 0.5 grams to 5 grams, may be injected into the hollow interior 46 of the golf club head 42 for selective weighting thereof.

[0126] The depth of the club head 42 from the striking plate portion 72 to the rear section of the crown portion 62 preferably ranges from 3.0 inches to 4.5 inches, and is most

preferably 3.5 inches. The height of the club head 42, as measured while in striking position, preferably ranges from 2.0 inches to 3.5 inches, and is most preferably 2.50 inches. The width of the club head 42 from the toe section 68 to the heel section 66 preferably ranges from 4.0 inches to 5.0 inches, and more preferably 4.4 inches.

[0127] FIG. 10 illustrates the axes of inertia through the center of gravity of the golf club head. The axes of inertia are designated X, Y and Z. The X axis extends from the striking plate portion 72 through the center of gravity, CG, and to the rear of the golf club head 42. The Y axis extends from the toe section 68 of the golf club head 42 through the center of gravity, CG, and to the heel section 66 of the golf club head 42. The Z axis extends from the crown portion 62 through the center of gravity, CG, and to the sole portion 64.

[0128] As defined in *Golf Club Design, Fitting, Alteration & Repair*, 4th Edition, by Ralph Maltby, the center of gravity, or center of mass, of the golf club head is a point inside of the club head determined by the vertical intersection of two or more points where the club head balances when suspended. A more thorough explanation of this definition of the center of gravity is provided in *Golf Club Design, Fitting,*

Alteration & Repair.

[0129] The center of gravity and the moment of inertia of a golf club head 42 are preferably measured using a test frame (X^T, Y^T, Z^T), and then transformed to a head frame (X^H, Y^H, Z^H), as shown in FIGS. 11 and 11A. The center of gravity of a golf club head may be obtained using a center of gravity table having two weight scales thereon, as disclosed in co-pending U.S. Patent Application Number 09/796,951, filed on February 27, 2001, entitled High Moment Of Inertia Composite Golf Club, and hereby incorporated by reference in its entirety. If a shaft is present, it is removed and replaced with a hosel cube that has a multitude of faces normal to the axes of the golf club head. Given the weight of the golf club head, the scales allow one to determine the weight distribution of the golf club head when the golf club head is placed on both scales simultaneously and weighed along a particular direction, the X, Y or Z direction.

Table One

Head	Volume	Mass	Head Mass	Discreet Mass	COR	Material	Process
Ex.1	430cc	270g	197g	73g	0.85	Ti 6-4	cast
Ex.2	510cc	285g	200g	85g	0.896	Ti 10-2-3	Machnd
Ex. 3	385cc	285g	198g	84g	0.884	Ti Alloy	Forged

[0130]

Table Two

Head		Ixx	Iyy	Izz	Ixy	Ixz	Iyz
Ex.1		2800	2545	4283	197	7	128
Ex. 2		3232	2631	4263	230	-116	246
Ex. 3		2700	2200	3600	37	21	320

[0131] Table One lists the volume of the golf club heads 42, the overall weight, the weight of the head without weight members, the mass of the weight member 122, the coefficient of restitution ("COR") on a scale from 0 to 1 using the USGA standard test, the material of the face component, and the process for manufacturing the face component 60. Example 1 is a 430 cubic centimeter golf club head 42 with the total club weighing 270 grams. The face component 60 is composed of a cast titanium, Ti 6-4 material. The aft body 61 is composed of a plurality of plies of pre-preg. The golf club head 42 has a loft angle of eleven degrees and a lie of 54 degrees. The bulge radius is 11 inches and the roll radius is 10 inches. The vertical distance "h" of the club head of example 1 is 2.14 inches, and the distance "w" is 3.46 inches. Example 2 is a 510 cubic centimeter golf club head 42 with the total golf club weighing 285 grams. The face component 60 is composed of a forged titanium alloy material, Ti 10-2-3. The aft body 61 is composed of a plurality of plies of pre-preg.

The bulge radius is 11 inches and the roll radius is 10 inches. The vertical distance "h" of the club head of example 2 is 2.54 inches, and the distance "w" is 3.9 inches. Example 3 is a 385 cubic centimeter golf club head 42 with the total golf club weighing 198 grams. The face component 60 is composed of a forged titanium alloy material. The aft body 61 is composed of a plurality of plies of pre-preg. The golf club head 42 has a loft angle of eleven degrees and a lie of 54 degrees. The bulge radius is 11.5 inches and the roll radius is 10 inches. The vertical distance "h" of the club head of example 3 is 2.16 inches, and the distance "w" is 3.60 inches.

[0132] Table Two lists the moment of inertia for exemplary golf club heads 42 of Table One. The moment of inertia is given in grams-centimeter squared ("g-cm^{2}"). For example 1, the center of gravity is located at 0.901 inch in the X direction, 0.696 inch in the Y direction, and 1.043 inches in the Z direction. For example 3, the center of gravity is located at 0.654 inch in the X direction, 0.645 inch in the Y direction, and 1.307 inches in the Z direction.

[0133] In general, the moment of inertia, Izz, about the Z axis for the golf club head 42 of the present invention will range

from 2800g-cm^2 to 5000g-cm^2, preferably from 3000g-cm^2 to 4500g-cm^2, and most preferably from 3750g-cm^2 to 4250g-cm^2. The moment of inertia, Iyy, about the Y axis for the golf club head 42 of the present invention will range from 1500g-cm^2 to 2750g-cm^2, preferably from 2000g-cm^2 to 2400g-cm^2, and most preferably from 2100g-cm^2 to 2300g-cm^2.

[0134] In general, the golf club head 42 has products of inertia such as disclosed in U.S. Patent Number 6,425,832, which was filed on July 26, 2001 and is hereby incorporated by reference in its entirety. Preferably, each of the products of inertia, Ixy and Ixz, of the golf club head 42 has an absolute value less than 100 grams-centimeter squared.

[0135] FIGS. 15-15E illustrate various embodiments of golf club heads 42, each having an aft-body 61 with a different arrangement of one or more weight members 122 in various locations of the aft-body 61 to alter the location of the center of gravity of the golf club head 42, thereby improving golf club performance (trajectory and shot shape) for different player types. FIG. 15 illustrates a golf club head 42 with a weight member 122 positioned at the center of the ribbon section 90 of the golf club head 42, preferably for a neutral bias center of gravity location for the golf

club head 42. The weight member 122 is shown in dashed lines for FIGS. 15-15E since the weight member 122 is placed on the interior of the aft-body 61. However, those skilled in the pertinent art will recognize that the weight member 122 may be placed on the exterior surface of the aft-body without departing from the scope and spirit of the present invention.

[0136] FIG. 15A illustrates a golf club head 42 with a weight member 122 positioned in the ribbon section 90 of the aft-body 61 nearer the heel end of the golf club head 42, preferably for a heel bias center of gravity location for the golf club head 42.

[0137] FIG. 15B illustrates a golf club head 42 with weight members 122a and 122b positioned in the ribbon section 90 of the aft-body 61 equidistant from each other to preferably provide the golf club head with a neutral bias center of gravity location and a greater moment of inertia.

[0138] FIG. 15C illustrates a golf club head 42 with weight members 122a and 122b positioned in the ribbon section 90 equidistant from each other and a third weight member 122c positioned below weight members 122a and 122b to preferably provide the golf club head with a neutral bias center of gravity location and a greater moment of inertia.

[0139] FIG. 15D illustrates a golf club head 42 with weight members 122a and 122b positioned in the ribbon section 90 equidistant from each other and weight members 122c and 122d positioned below weight members 122a and 122b and equidistant from each other to preferably provide the golf club head with a neutral bias center of gravity location and a greater moment of inertia.

[0140] FIG. 15E illustrates a golf club head 42 with weight members 122b and 122d positioned in the center of the golf club head 42 and weight members 122a, 122c and 122e positioned near the heel end of the golf club head 42 to preferably provide a golf club head with a heel bias center of gravity location and a greater moment of inertia. Weight members 122c and 122d are positioned in the ribbon section 90 of the aft-body 61 with weight members 122a and 122b positioned above the ribbon section 90 and weight member 122e positioned below.

[0141] FIGS. 16 and 16A illustrate a golf club head 42 with a bias line 300 partitioning the golf club head 42 into a heel bias area 301 and a toe bias area 302.

[0142] FIGS. 17 and 17A illustrate a golf club head 42 with a first bias line 310 and a second bias line 311, which partition the golf club head 42 into a heel bias area 312, a neutral

bias area 313 and a toe bias area 314.

[0143] FIGS. 18 and 18A illustrate a golf club head 42 with a first vertical bias line 320, a second vertical bias line 321, and a horizontal bias line 322, which partition the golf club head 42 into a high heel bias area 323, a low heel bias area 324, a high neutral bias area 325, a low neutral bias area 326,a high toe bias area 327, and a low toe bias area 328.

[0144] FIGS. 19 and 19A illustrate a golf club head 42 with a first vertical bias line 330, a second vertical bias line 331, a first horizontal line 332 and a second horizontal bias line 333, which partition the golf club head 42 into a high heel bias area 334, a center heel bias area 335, a low heel bias area 336, a high neutral bias area 337, a center neutral bias area 338, a low neutral bias area 339, a high toe bias area 340, a center toe bias area 341, and a low toe bias area 342.

[0145] FIGS. 20 and 20A illustrate a golf club head 42 with a first bias line 350 and a second bias line 351, which partition the golf club head 42 into a rear heel bias area 352, a forward heel bias area 353, a rear toe bias area 354 and a forward toe bias area 355.

[0146] FIGS. 21 and 21A illustrate a golf club head 42 with a first

vertical bias line 360, a second vertical bias line 361, a first horizontal line 362, a second horizontal bias line 363, a first lateral line 364 and a second lateral line 365, which partition the golf club head 42 into a rear high heel bias area 370, a mid high heel bias area 371, a forward high heel bias area 372, a rear center heel bias area 373 (not shown), a mid center heel bias area 374 (not shown), a forward center heel bias area 375, a rear low heel bias area 376 (not shown), a mid low heel bias area 377 (not shown), a forward low heel bias area 378, a rear high neutral bias area 380, a mid high neutral bias area 381, a forward high neutral bias area 382, a rear center neutral bias area 383 (not shown), a mid center neutral bias area 384 (not shown), a forward center neutral bias area 385, a rear low neutral bias area 386 (not shown), a mid low neutral bias area 387 (not shown), a forward low neutral bias area 388, a rear high toe bias area 390, a mid high toe bias area 391, a forward high toe bias area 392, a rear center toe bias area 393 (not shown), a mid center toe bias area 394 (not shown), a forward center toe bias area 395, a rear low toe bias area 396 (not shown), a mid low toe bias area 397 (not shown), and a forward low toe bias area 398.

[0147] FIGS 22 and 23 illustrate the effect on side spin and back spin, respectively, by movement of the center of gravity of the golf club head 42. FIGS. 22 and 23 illustrate movement of 50 grams of discretionary mass (the weight members 122) in a golf club head 42 having a mass of 200 grams. To achieve a 0.050 inch movement of the Ycg or Zcg position of the center of gravity of the golf club head 42, a weight member 122 having a mass of 50 grams is preferably moved 0.20 inch in any direction (Ycg or Zcg). To achieve a 0.050 inch movement of the Ycg or Zcg position of the center of gravity of the golf club head 42, two weight members 122, each having a mass of 25 grams, are preferably both moved 0.20 inch in any direction (Ycg or Zcg) or one is moved 0.40 inch in any direction. To achieve a 0.050 inch movement of the Ycg or Zcg position of the center of gravity of the golf club head 42, three weight members 122, each having a mass of 17 grams are preferably all moved 0.20 inch in any direction (Ycg or Zcg), two are moved 0.30 inch in any direction (Ycg or Zcg), or one is moved 0.60 inch in any direction (Ycg or Zcg). To achieve a 0.050 inch movement of the Ycg or Zcg position of the center of gravity of the golf club head 42, four weight members 122, each having a mass of 12.5

grams are preferably all moved 0.20 inch in any direction (Ycg or Zcg), three are moved 0.27 inch in any direction (Ycg or Zcg), two are moved 0.40 inch in any direction (Ycg or Zcg), or one is moved 0.80 inch in any direction (Ycg or Zcg). Those skilled in the pertinent art will recognize that other variations with more weight members of varying masses may be used to control the center of gravity of the golf club head without departing from the scope and spirit of the present invention.

[0148] The present invention provides a golf club that can be tailored to a particular golfer. By providing a face component 60 and various, interchangeable aft-bodies 61, each of which has a different arrangement of weight members 122, similar style golf club heads with different center of gravity locations can be produced. The location of the center of gravity of the golf club head 42 affects the spin characteristics of the golf club head. The choice a particular face component 60 and aft-body 61 combination will depend on the needs of the specific golfer. For example, a golf club with a tendency to provide a draw shot shape would be better suited for golfers who tend to hit a fade or slice. In addition, a golf club with a tendency to provide a higher ball trajectory would be better suited for golfers

who tend to hit golf balls lower than desired.

[0149] In order to provide a golfer with a customized club, the golfer's swing and ball striking performance must be known or determined. One such method of predicting a golfer's ball striking performance is disclosed in U.S. Patent Number 6,506,124, which is hereby incorporated by reference in its entirety. The optimal golf club head center of gravity location is then determined based on the golfer's performance, and the appropriate aft-body 61 is selected. The aft-body 61 is then attached to the face component 60 to provide a custom golf club head 42.

[0150] From the foregoing it is believed that those skilled in the pertinent art will recognize the meritorious advancement of this invention and will readily understand that while the present invention has been described in association with a preferred embodiment thereof, and other embodiments illustrated in the accompanying drawings, numerous changes, modifications and substitutions of equivalents may be made therein without departing from the spirit and scope of this invention which is intended to be unlimited by the foregoing except as may appear in the following appended claims. Therefore, the embodiments of the invention in which an exclusive property or privilege is

claimed are defined in the following appended claims.